WORK PLAN

GROUND AND SURFACE WATER QUALITY ASSURANCE PLAN, SAMPLING AND PROJECT WORK FOR THE 5-YEAR JOINT HYDROLOGIC STUDY AT KENNECOTT'S UTAH COPPER DIVISION MINE

SALT LAKE COUNTY, UTAH

Prepared by: Terry D. Vandell
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Approved by: Dames & Moore
Date: 1985

Intera Technologies
Date: 1985

UCD Ground Water Study Technical Group
Utah State Department of Health
Salt Lake County Flood Control
and Water Quality
Date: 1985

Environmental Protection Agency
Region VIII
Date: 1985

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Distribution of Plan:

Steve D. Taylor
Dames & Moore
Intera Technologies

State: Steve McNeal
Kent Gray
Ken Bousfield
Marv Maxell
Joel Hebdom
Jim Salmon

County: Terry Way

EPA: Rob Walline, Region VIII

1.0 INTRODUCTION

This plan presents the quality assurance guidelines and work plan for ground and surface water quality sampling being performed at Kennecott's Utah Copper Division Mine in Salt Lake County, Utah. This plan has been developed by Kennecott and reviewed by Kennecott's consultants, the Salt Lake County Health Department and the Technical Group comprised of Kennecott and the seven state and county technical staff members (Utah State Department of Health and Salt lake County Flood Control and Water Quality) working on the five-year ground-water study at Kennecott's Utah Copper Division Mine. The Advisory Group (comprised of one Kennecott representative, the Director of the Department of Health of the State of Utah and the Director of the Salt Lake County Flood and Water Quality Division) and by EPA Region VIII aid in study work implementation. The study area encompasses approximately 200 square miles with 51 Kennecott monitor wells, 64 private wells and 30 surface water sites. This study was begun in June, 1983. Figure 1 attached shows the study area boundaries and Table 1.0 describes them.

The purposes for this study are to: 1. Evaluate existing and potential adverse impacts to human health and the environment from impacts to groundwater from Kennecott and pre-Kennecott mining operations in the Oquirrh Mining District, and 2. Based on the contaminant point sources and lateral and vertical extent of ground-water contamination, identify potential remedial actions.

In order to define any existing offsite releases to the groundwater, Kennecott will complete a Phase I drilling program aimed at filling in data gaps, particularly offsite, in areas likely to be impacted, and on-site, where contaminants are found, but need to be better defined for the preliminary modeling effort.

The Phase II drilling program will be based on the results of the Phase I drilling and sampling and the preliminary contaminant flow model. The Phase II drilling program will be site-specific to the contaminant point sources. Details of the Phase II drilling program will be developed after Phase I drilling and sampling are completed and the data are evaluated.

TABLE 1.0

STUDY AREA DESCRIPTION[1]

Township	Range	Sections
2S	1E	7, 18, 19, 30, 31
2S	1W	7-36
2S	2W	7-36
2S	3W	9-16, 21-28, 33-36
3S	1E	6, 7, 18, 19, 30, 31
3S	1W	1-36
3S	2W	1-36
3S	3W	1-4, 9-16, 21-28, 33-36
4S	1E	6, 7, 18, 19
4S	1W	1-24
4S	2W	1-24
4S	3W	1-4, 10-12, 13-15, 22-24

(1) See Figure 1 attached.

2.0 PROJECT DESCRIPTION: OBJECTIVES AND WORK SCOPE

General objectives

The scope of the five year hydrogeologic/hydrologic study was developed by Kennecott and the Technical and Advisory groups and reviewed by Kennecott's environmental consultants, Dames & Moore and Intera Technologies.

The five year study is to accomplish the following:

1. Evaluate the natural resources, the socioeconomic conditions, hydrogeology and hydrology in the vicinity of the Bingham Canyon Mining District.

2. Assess the historic (to determine background, where possible), and existing ground and surface water quality conditions in the vicinity of the Bingham Canyon Mining District, particularly with respect to the impacts from Kennecott's mining operations.

3. Obtain the necessary hydrogeologic and geochemical data required to evaluate the lateral and vertical extent of ground-water contamination.

4. Estimate contaminant movement in the groundwater based on source areas, actual field and laboratory water quality data, water level data, analytical and numerical solutions to ground-water contaminant flow equations and a ground-water contaminant flow model. Contaminant recharge rates can be approximated indirectly from the contaminant flow model.

5. List the potential remedial actions for implementation to solve the ground-water contaminant problems.

General Work Scope

The scope of work required to complete the five year study includes:

1. Review, compilation and summary of available natural resource, socioeconomic, hydrogeologic and hydrologic information in the UCD mine area (draft EAS, October 1984).

2. Continued collection, analysis and evaluation of water samples from existing and new monitor wells, private wells and surface water sample sites (1983-1989), (See Table 2 attached).

3. Drilling, logging, and sampling at new monitor well sites, (beginning in 1985), in strategic hydrogeologic locations, (both lateral and vertical), where definition of hydrogeologic conditions is determined to be critical. Phase I drilling will evaluate potential existing offsite releases; Phase II drilling will evaluate on-site contaminant sources.

4. Collection of geologic and water samples, during new monitor well drilling, at various depths, to evaluate vertical changes in lithology and water quality (1985).

5. Completion of a series of column and geochemical tests to evaluate the attenuation characteristics of the subsurface materials (1985-1986) and for completion of a contaminant flow model.

6. Preparation of five annual progress reports and completion of a final environmental impact assessment (1989) to include potential remedial action.

Work Completed To Date

Report 1, June 1984, summarizes published hydrogeologic data pertinent to the study and presented geologic, hydrologic and hydrogeologic data which Kennecott has obtained in the mine area at the Utah Copper Division.

Most of the Round 1 (1983-1984) comprehensive laboratory water quality data results from existing Kennecott monitor wells, surface water sites and private wells (excluding several irrigation wells) and 1982 water quality data were evaluated and are included in Report 1. Any additional Round 1 1984 water quality data, historic water quality data from 1975, natural resource data and socioeconomic information is presented in the October, 1984 draft EAS.

Definition of existing ground and surface water conditions is still somewhat difficult and must be considered as preliminary, subject to change as the historic water quality data are evaluated in detail as additional hydrogeologic data and water quality data are obtained from new strategically located monitor wells.

Specific Project Work Tasks Completed To Date Include

1. A field inventory of Kennecott monitor wells. A total of 51 Kennecott monitor wells were sampled, as indicated in Table B-1, Appendix B, Report 1.

2. Unuseable Kennecott monitor wells (19) were grouted to prevent potential deep aquifer contamination (Table B-1, Appendix B, Report 1).

3. A well inventory of private wells in the study area was completed. Well depths and open zones, water level data, well use, well location and well owner information were obtained from the Utah State Engineer's Office and from field investigations and are included in Appendix F, Report 1. Well logs of private wells and Kennecott wells are included in Addendum 1, Report 1.

4. A total of 51 Kennecott monitor wells were sampled, tested in the field for conductivity, temperature, pH, carbonate and bicarbonate, and analyzed for a comprehensive number of constituents in Kennecott's laboratory.

5. A total of twenty five (25) springs and streams and five (5) Kennecott facilities were sampled for comprehensive laboratory analyses and field tested for conductivity, temperature, pH, carbonate and bicarbonate.

6. Sixty-four (64) representative private water wells which could be sampled were sampled for Round 1 analyses.

7. Laboratory analyses were extensive and included analyses of 45 constituents at all sample sites and 57 constituents (which also included organics and radionuclides) at a few selected sample sites. Total as well as dissolved metals concentrations were analyzed.

   The field and laboratory sampling and analyses collected since 1975 and the 5-year study were conducted according to EPA recommended procedures. The results of the laboratory analyses and the field information Round 1 water quality sample site sheets are included in Appendices B and C, Report 1 respectively.

   The more detailed borehole geophysical logs, and borehole geologic logs and well construction data are included in Addendum 1, Report 1. However, all available geologic logs are available at Kennecott's downtown office.

   The work conducted for the draft EAS completion (October, 1984) included:

   1. Evaluation of all Round 1 water quality sample results.

   2. Evaluation of all historic water quality data back to 1975.

   3. Preliminary socioeconomic, natural resource and water use evaluations.

8. Round 2 water quality sampling and analyses have been completed with data evaluation ongoing for Report II completion in June, 1985.

<u>Future Project Work Tasks And Estimated Completion Times</u>

- Phase I monitor well drilling to better define on-site and off-site sub-surface conditions in both lateral and vertical directions (1985 - mid-1986).

- Phase II monitor well drilling to better define on-site contaminant source areas and plume movement in both lateral and vertical directions (1986 - mid-1987). One upgradient and two downgradient wells will be completed at source areas, where feasible. Only where extremely complex sub-surface conditions prevail will additional wells be drilled.

- Aquifer pumping tests to define transmissivities, permeabilities, storage coefficients, the confining bed(s)' integrity to restrict inter-aquifer flows, at existing and/or new well sites, in critical areas of contamination (1986 - mid-1987).
- Ongoing refinement of geologic cross-sections as new sub-surface geologic data are obtained (Annual Reports 3, 4 and 5 in 1986, 1987 and 1988).

- o At key monitor well sites near contaminant source areas, horizontal and vertical laboratory permeabilities at 10 foot intervals in the unsaturated zones and within each distinct saturated stratigraphic zone (1985 - mid-1987).

- o Slug tests will be conducted in all new monitor wells (1985 - mid-1987).

- o Continued annual and selected tri-annual water quality sampling and water level monitoring at existing and new monitor well sites. Monthly sampling will continue at evaporation pond monitor well sites W337, 338, 309, 310, 311 and 312.

- o Upgrading of water level contour maps to refine ground-water flow rates and directions, in both the shallow and deep aquifers.

- o Where and if necessary to define sub-surface contaminant movement, soil infiltration and soil contaminant retardation studies will be conducted by Intera Technologies (1986-1987).

- o The final EIR will identify (1) aquifer and confining unit geometries; (2) ground-water quality, movement, occurrence and productivity; (3) ground-water flow controls and recharge/discharge areas; (4) recharge/discharge rates, where possible; (5) confining units' integrities; (6) ground-water contaminant flow rates and directions via actual data and use of the ground-water contaminant flow model (1989).

- o Contaminant migration mechanisms that shall be considered by Intera Technologies for the model are: surface water to ground-water contaminant movement; losing and gaining surface water delineation; where appropriate, soil properties to evaluate infiltration and retardation of contaminants; unsaturated zone properties needed to estimate contaminant transport; soil chemistry properties, where needed, to estimate contaminant movement through soils (1985-1987).

- o Contaminant properties that need to be defined are: (1) a list of contaminants, (2) the physical and chemical properties of the contaminants, (3) estimates of the quantities of individual contaminants available for release, (4) mobility, persistence and effects of individual contaminants, (5) potential modes of individual contaminant releases, and (6) estimates of contaminant movement from existing contaminant source areas.

The work scope and rationale for the Phase I drilling is presented herein. The purpose of this five-year study is to evaluate Kennecott's potential impact to human health and the environment. Kennecott is concerned that there is existing offsite ground-water contamination. The Phase I drilling program is designed to evaluate the ground-water quality in areas that may already be impacted, but where there are currently no wells to monitor. Phase II drilling will focus in on site specific contaminant sources, upgradient and downgradient. Detailed specifications for Phase II drilling will be completed after the data from Phase I well drilling and sampling have been evaluated in conjunction with the existing monitor well site data. March, 1985 technical recommendations from EPA Region VIII, the Utah Department of Health, the Utah Geologic and Mineral Survey, the Utah Division of Oil, Gas and Mining and the Utah Water Research Laboratory at U.S.U. will be included in the Phase II drilling program.

TECHNICAL BASIS FOR PHASE I MONITOR WELL LOCATIONS AND DEPTHS

I. Well Depths

The well depths for all of these sites are rough estimates based on ground surface elevation, estimated depths to the first water table (see Figure 18 from Report 1 attached) and estimated thicknesses of low permeability zones (i.e. confining units) separating the upper shallow water table from the deeper aquifer.

These are rough estimates at best. Where shallow, intermediate and/or deep wells are scheduled to be drilled, the deepest well will be drilled first, cuttings logged and geophysically logged to evaluate (1) depth to first water and depth of the shallowest well (2) low permeability "confining" zones and (3) deeper high permeability transmissive zones along which deeper major ground-water flows would be encountered (i.e. the lower aquifer or at least the lower most permeable zones beneath the first saturated zone). The purpose in so doing is to complete monitor wells in the shallow aquifer and deeper aquifer.

Attached is Table 1 with the well designations, ground elevations, estimated depth to water elevations and estimated drilling depths.

II. Well Locations

As presented and agreed to at the February 19, 1985 Technical Group Meeting, the basis for the final well locations as shown on the attached Figure 2 are as follows:

- Sites 1(S,I,D), 2(S), 3(S) and 4(S) are located approximately .5 to 1 mile east of the leach dumps to better define the subsurface geology and to better define the contaminant plume along the leach dumps. Sites 1(S,I,D) and 2(S) are upgradient of the Lark tailings.

- Site 5(S,I,D) is upgradient of the 500 million gallon reservoir, along the Bingham Creek channel.

- Sites 6(S) and 7(S,I) are north and east of the 500 million gallon reservoir, offsite, to define the subsurface geology and to fill in the water quality data gaps which exist due to the fact that the existing Kennecott monitor wells in this area are no longer sampleable (i.e. wells have caved in or were destroyed).

  These two sites were relocated by the Technical Group, as shown at the February 19, 1985 Technical Group meeting.

- Sites 8(S,I), 9(S), 10(S,I), 11(S,D) are as located, to fill in gaps in the subsurface geologic data and ground-water quality data which exist offsite which may show some contamination from historic discharges along Bingham Creek and from historic untreated discharges to the old unlined evaporation ponds.

- Site 12(S,D) wells were completed in 1984 to evaluate the shallow and deep contamination near wells P198 and P199. Well P198 had shown contamination in 1983-1984. Well P198 is a deep well (510-520' open), but evidently is receiving shallow contamination from the upper aquifer. Well 12D = P240B (280-360' open), did not indicate contamination at depth and well 12S = P240A (100-150' open) did show contamination.

  Note: Well P240B was not completed at (510-520') as at P198 and as agreed to by the Technical Group, because although P240B was drilled to 530', the entire interval from 360 to 530' was silt and clay. The contamination in P198 is therefore from surface contamination along the sides of the casing. Well P198 should therefore be considered for grouting and abandonment.

- Site 13(S,D) is located near Mr. Wells and Mr. Ham's wells, which showed contamination in late 1984-1985. Water quality data from these two new wells will determine if the contamination at the Wells and Ham sites is due to vertical seepage along their well casings or lateral contaminant plume movement from the evaporation ponds.

- Site 14(S,D) is located along an old delta between the old and new evaporation ponds to monitor shallow and deep water quality in this area where a data gap exists.

- Site 15(S,I) is located at well site P202C to determine if the deep contamination at P202C (560-600' open) is real or is occurring due to vertical seepage along the casing. Well 15I = P241B was completed in 1984 but not yet sampled. P241B was drilled to 595' but open from 530-570' in the permeable zone.

- Site 17(S), as recommended by the Technical Group, is located to monitor the groundwater between the new evaporation ponds and the homes along 11,800 South where basement flooding occurred in 1984.

- Site 16(S,I) is located between the new lined evaporation ponds and Riverton City's wells, to monitor any potential impacts to their wells from the new evaporation ponds. Although Riverton City's wells are not located downgradient from the ponds, Kennecott has agreed to locate a monitor well at this site.

TABLE 1 ESTIMATED WELL DEPTHS

Well Designation	Geologic** Units	Estimated*** Well Depth (in ft)	Anticipated*** Screen Interval (in ft)	Approx. Ground Elevation	Approx. Water Level - Elevation	Approx. Depth To = Water
1S	Tv	160	120 - 160	5640	- 5500	= 140
1I	Tv	300	260 - 300		-	-
1D	Tv	360	340 - 360		-	-
2S	Tal, Tv	120	80 - 120	5500	- 5400	= 100
3S	Tv	120	80 - 120	5500	- 5400	= 100
4S	Tal, Tv?	220	180 - 220	5500	- 5300	= 200
5S	Tal, Tv?	220	180 - 220	5400	- 5200	= 200
5I	Tal, Tv?	300	260 - 300		-	-
5D	Tal, Tv?	350	310 - 350		-	-
*6S	Tal, Tv?	130	90 - 130	5360	- 5250	= 110
*7S	Qal, Tal?	330	290 - 330	5160	- 4850	= 310
*7I	Qal, Tal?	350	320 - 350		-	-
*8S	Qal	220	180 - 220	4880	- 4675	= 205
*8I	Qal	300	260 - 300		-	-
9S	Qal	160	120 - 160	4450	- 4310	= 140
10S	Qal	300	260 - 300	4520	- 4240	= 280
10I	Qal	350	320 - 350		-	-
11S	Qal	300	260 - 300	4510	- 4230	= 280
11D	Qal	350	310 - 350		-	-
*13S	Qal	50	25 - 50	4625	- 4600	= 25
*13D	Qal	300	260 - 300		-	-
14S	Qal	150	110 - 150	4780	- 4650	= 130
14D	Qal	300	260 - 300		-	-
15S	Qal	350	320 - 350	5100	- 4800	= 300
16S	Qal	200	160 - 200	4650	- 4470	= 180
16I	Qal	300	260 - 300		-	-
17S	Qal	125	185 - 125	4650	- 4550	= 100

Total Footage = 6715 ft.

* Relocated by the Technical Group.

** Geologic Units

- Qal - Quaternary alluvial and sediments of Lake Bonneville
- Tal - Tertiary alluvial sediments
- Tv - Tertiary volcanic rocks (may include some intrusive igneous rocks)

*** Final depths will not be specified until borings have been geophysically logged.

TABLE 2. LIST OF SAMPLE SITES TO MONITOR

Private Well Sites			Well Use(s)[3]
	W22	J. Dansie[4]	D, Ir
	W27	Conoco Station[5]	A
(2)	W31	Copperton[4]	D
(1)	W41A	Bastian	D, Ir
	W107	Westland Hills #1?	Ir, D, St
	W108	Westland Hills #2?	Ir, D
(2)	W125	Nicoletti	K
(2)	W131A	C. Fassio[4]	D, St
	W131B	C. Fassio	D, St
	W134	O. Madsen[4]	D
(2)	W136	Garamedi (Riverton City Well)[4]	D
	W141	K. Motoki[4]	D
	W142	Bills	D, Ir
	W144	M. Jensen	D
	W146	D. Boulden[4]	D
(2)	W151	P. Schmidt[4]	D, Ir
	W152	O. J. Wilkinson[4]	D
	W153	F. E. Smith	D
(2)	W154	P. Groves[4]	D
	W155	W. Davis	A
	W162	Leo Palmer	D
(2)	W164	Garrett	D
	W167	Mulch Plant	D
	W173	Hamilton Feed & Livestock	D, Ir
(2)	W174	Gardiner	D
(2)	W176	Peterson[4]	D
	W178	Gardner[4]	St
	W180	Fur Breeders[4]	D, St
	W182	Vance Beakstead[4]	D, St
(2)	W185	Herriman City[4]	D, Ir
(1,2)	W189	Interstate Brick[5]	D, In
(1)	W300	Fraughton[4]	D, Ir, St
(1)	W301	Anderson[4]	Ir, D, St
	W302	Naylor[4][5]	Ir
	W304	Farnsworth[4]	Ir, D, St
	W305	Tac	D, Ir
	W306	Gigi[4]	Ir
	W308	Tolbert	D
(1,6)	W309	L. R. Bateman[4]	D
(1,6)	W310	Bowles[4]	D
(1,2,6)	W311	Schouton[4]	D
(1,6)	W312	Tidwell[4]	D
(2)	W322	Brent Dansie	D
	W323	L. Wall[4]	D, Ir, St
(2)	W325	J. Holland[4]	D
(2)	W326	Hamilton (Riverton City Well)[4]	D
(2)	W327	Maynard (Riverton City Well)[4]	D
(2)	W328	Gedge (Riverton City Well)[4]	D

Private Well Sites			Well Use(s)[3]
(1)	W329	A. Jensen (Webb)	D
	W331	Jay N. Butterfield[4]	D
	W332	Paul Solmonsen	D
(1)	W333	Thad Otley[4]	D
	W334	Bob Goldsmith[4]	D
	W335	Dick Kunz	D
	W336	Gary Larsen	D
	W337	Bill Ham[5]	D
	W338	Flossie Wells[5]	D
	W339	R. K. Petersen[4]	D
	W340	Harmon	D, Ir
	W341	Murray Fair Grounds[4]	D
	W342	Murray Fair Grounds[4]	D
	W345	D. H. Greenwood	D
	W346	Pine Hollow Tree Farm	D
	W347	D. H. Holtkamp	D
(1)	W348	Blaine Christensen	D
	W359	Hercules	D
	W360	Kelly Schultz	D
(1,2)	W361	West Jordan City Well[5]	D

Footnotes for W wells in addition to the comprehensive analysis in Table 4-1:

(1) Sample for coliform
(2) Sample for radionuclides (All new monitor wells will be sampled at least once for radionuclides)
(3) Well use codes, based on actual use or permitted use as per the Utah State Engineer's well log records. The first use code designates the key or current use for the wells.
Ir = Irrigation
D = Domestic
K = Kennecott Monitor Well
In = Industrial
A = Abandoned, not used
St = Stock Watering
(4) Well owners who have requested and received water quality data results on their wells.
(5) Will be sampled 3 times/yr., twice only for critical contaminant parameters (i.e. the field parameters, TDS, SO_4, Cu, Fe, Mn, Zn, Pb).
(6) These are generally sampled monthly as evaporation pond monitor wells.

K & P Well Sites[6]

	K26
	K60
(2)	K70
	K72
(1)	K84[5]
(1)	K100
(2)	K105
	K106
(2)	K109
	K120

K & P Well Sites[6]

(1,2) K201
K349[5]
P190A
P190B
P191A
P191B
P192A
(2) P192B
P193A
P193B
P194A
P194B
P196A
P197A
P197B
(2) P198
(2) P199
P202C
(1,2) P207A
(1) P207B
(1) P208A
(1) P208B
P209B
P210B
P211A
P211B
P212A
P212B
P213B
P213C
P214A
P214B
P220
P225
P228
P231
(2) P234
(2) P239 replacement near old K67R
(2) P240A replacement near old P198A[5]
(2) P240B replacement near old P198B[5]
(2) P241A replacement near old P202B[5]
(2) P241B replacement near old P202C[5]

Footnotes in addition to the comprehensive analysis in Table 4-1:

(1) Sample for coliform
(2) Sample for radionuclides (All new monitor wells will be sampled at least once for radionuclides)
(5) These sites shall be sampled three times/year, twice only for the critical contaminant parameters (i.e. the field parameters, TDS, SO_4, Cu, Fe, Mn, Zn, Pb; to evaluate seasonal fluctuations, if any).
(6) Additional new wells will be sampled as these new monitor wells are constructed.

S Sites

(2)	S1	J. River 9000 S.
	S2	J. River 12300 S.(5)
	S21	Butt. Creek above Lark Mine(5)
	S21A	Bingham Mine Portal Drain
(1)	S21B	Butt. Creek and Bingham Mine Portal
	S22A	Lark Town Spring
	S22B	Butt. Creek Spring
	S33	Provo Reservoir Canal 16150 S.
	S33A	Provo Reservoir Canal 9000 S.
	S38	J. River 10,600 S.
	S40	Old Scout Camp Spring
(2)	S53	U.S. Mine Butt. Creek Portal
	S54	J. River 6400 S.
	S56	N. Bingham Creek
	S57	J. River 8000 S.
	S166	J. River 14600 S.
(1,2)	S200	Bingham Reservoir(5)
(2)	S236	Leach Fluid
(2)	S237	Bingham Pit Waters
	S313	J. River 4800 S.
(2)	S314	N. Jordan Canal
	S315	Butt. & Midas Creek
	S316	Crystal Springs
(2)	S317	S. Kennecott Mine Dumps Drainage
(2)	S318	Barney's Springs
	S319	Maple Springs
(2)	S320	Dry Fork Creek
(2)	S321	Midas Creek
(2)	S324	6400 W. 14000 S. Rose Creek
	S330	J. River 9400 S.
	S343	1370 W. 7300 S. (Spring)
	S344	7560 S. 1200 W. (Spring)
	S350	Evaporation Ponds (3, 4, 5 (5)
	S351	40th West Pond
(1,2)	S352	S. Evaporation Ponds(5)
	S353	Small Reservoir
(1,2)	S354	Treated Mined Stream = old S238 designation
	S355	Nose & Mine Combo. Stream (untreated)
(2)	S356	80 acre pond
	S357	Jordan River eff.
	S358	Cemetery Pond

Footnotes in addition to the comprehensive analysis in Table 4-1:

(1) Sample for coliform
(2) Sample for radionuclides
(5) Will be sampled 3 times/year; once for comprehensive analysis twice for key contaminants only

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

3.1 ORGANIZATION

The following gives the organization for the activity:

Project Manager
Steven D. Taylor

Technical Manager
Terry D. Vandell

Kennecott
Laboratory Manager
Lynn Hutchinson

Staff
Kennecott Staff

Project Quality Assurance Advisors
Utah Ground-Water Technical And Advisory Groups

- o State of Utah Department of Health
- o Salt Lake County Flood Control And Water Quality
- o Salt Lake City-County Health Department
- o Kennecott
- o Dames & Moore
- o Intera Technologies

Sampling activities performed by Kennecott environmental technicians will be conducted under the direction of Ms. T. D. Vandell and in accordance with this QA plan.

3.2 RESPONSIBILITIES

The Project Manager will have overall responsibility for direction of the project, quality control, reporting, finance and contracts.

The Technical Manager will prepare QA plans for review and will be responsible for execution of the activity in accordance with the plan.

The Laboratory Manager will prepare Quality Assurance laboratory plans and reports for review semi-annually and will be responsible for execution of the activity in accordance with the plan.

The Project Quality Assurance Advisors will 1) review and advise on the QA plan, 2) review all quality control data, 3) identify problems and recommend corrective action as necessary, and 4) prepare a brief written statement at least annually in the yearly progress report, addressing precision and accuracy of the monitoring data, results of performance sample analyses, results of EPA/State audits, and corrective actions taken, pertinent to the project activity, as per the Laboratory Manager's semi-annual Quality Assurance laboratory reports.

3.3 HEALTH AND SAFETY

Kennecott employees are required to have MSHA training and must obey OSHA rules and regulations. Kennecott will ensure that all authorized visitors will be informed of the proper safety requirements and equipment required.

The field water quality sampling work includes very little risk with respect to potential accidents and safety, since Kennecott's contaminants are not toxic organic chemicals and sampling equipment is mostly automated. However, the monitor well drilling programs do involve substantially more risk with respect to potential accidents and safety.

Consequently, Kennecott requires, by terms of written contract document, that the contractor comply with the following:

Protective Equipment

Hard hats, preferably with full brims and manufactured of a non-electrical conducting material, safety glasses and safety shoes, as approved by Owner, will be provided by Contractor and will be worn at all times by Contractor's or subcontractors' personnel or any other persons entering Owner's property on behalf of Contractor. Other protective equipment will be utilized as specified in applicable statutes, rules or orders in effect in the State of Utah and as specified by Engineer.

Accident Prevention

Contractor must comply, and must enforce compliance by all subcontractors, with the highest standards of safety and accident prevention found in any of the following: (a) applicable laws, ordinances, building and construction codes, orders, rules and regulations (including those of Owner); (b) the latest edition of the "Manual of Accident Prevention in Construction" as published by the Associated General Contractors of America, Inc.; (c) the latest edition of the "Accident Prevention Manual for Industrial Operations," as published by the National Safety Council, Inc.; (d) the latest edition of the Utah Occupational Safety and Health Rules and Regulations" published by the Utah State Industrial Commission, and (4) the latest edition of the Federal Mine Safety and Health Act.

Laws, Ordinances, Permits, and Licenses

All articles and materials furnished hereunder will comply with such provisions of the Federal Occupational Safety and Health Act of 1970, and the Federal Mine Safety and Health Amendments Act of 1977 and regulations under said Acts as apply to the possession and use of such articles and materials by Owner and its agents and employees. In addition, Contractor shall advise Owner of any hazard or toxic substance which is present in, or may be encountered by, Owner and its agents and employees in using or possessing the articles or materials furnished hereunder and Contractor shall use its best efforts to minimize the hazard or toxicity thereof.

The the extent that the work contemplated herein requires the Contractor to conduct its activities in areas which are subject to the jurisdiction of Federal Mine Safety and Health Administration, State Occupational Safety and Health Acts, and/or Federal Occupational Safety Health Act of 1970 (herein collectively referred to as MSHA/OSHA Laws), Contractor shall use its best efforts to obtain a Contractor identification number as may be required or authorized under the MSHA/OSHA Laws. Contractor shall be responsible for compliance by Contractor and its subcontractors with all standards, rules and regulations promulgated under applicable MSHA/OSHA Laws and shall be responsible for any citations or orders issued thereunder arising out of work to be performed pursuant to this contract, including any assessment levied in connection therewith. Contractor agrees to hold Owner harmless from any citations or orders, or any assessments levied in connection therewith, issued pursuant to any MSHA/OSHA Law relating to, or arising out of, the work to be performed by Contractor, or any of its subcontractors, including reasonable attorneys fees incurred by Owner. The contract price set forth in the Agreement includes the cost of compliance with all MSHA/OSHA Laws, and applicable standards, rules and regulations promulgated thereunder, and Owner shall not bear any portion thereof.

4.0 ANALYTICAL PARAMETERS AND QA OBJECTIVES

Analytical parameters, their detection limits, method of analysis and hold times are given on Table 4-1. Specific conductance, carbonate, bicarbonate, temperature and pH will be measured in the field.

Acceptance criteria for routine laboratory QC checks will be within plus or minus two standard deviations of the precision and accuracy data as specified in the appropriate EPA methodology (Reference 5) and established by the certified laboratory.

TABLE 4-1

LABORATORY ANALYTICAL PARAMETERS AND METHODS

Parameter	Detection Limit (1)	EPA (10/26/84) Method No.	Maximum Hold Time
pH	±0.1 units	150.1	(3)
Specific conductance	±2% umhos/cm	120.1	(3)
Total dissolved solids	10.0	160.1	7d
Total suspended solids	1.0	160.2	7d
Aluminum	0.1	202.1	6mo
Arsenic	0.004	206.2	6mo
Barium	0.3	208.1	6mo
Cadmium	0.001	213.1	6mo
Chromium	0.01	218.1	6mo
Copper	0.02	220.1	6mo
Iron	0.03	236.1	6mo
Lead	0.01	239.2	6mo
Manganese	0.01	243.1	6mo
Mercury	0.0002	245.1	28d
Molybdenum	0.1	246.1	6mo
Calcium	0.1	215.1	6mo
Fluoride	0.1	340.2	28d
Magnesium	0.1	242.1	6mo
Potassium	0.1	258.1	6mo
Sodium	0.1	273.1	6mo
Carbonate	5.	310.2	(3)
Bicarbonate	5.	310.2	(3)
Chloride	1.0	325.2	28d
Nitrate (as N)	0.02	353.1	48hrs
Sulfate	3.0	375.2	28d
Alkalinity	5.0	310.2	14d
Zinc	0.01	289.1	6mo
Selenium	0.004	270.2	6mo
Silver	0.01	272.1	6mo
Coliform bacteria (4)	2.0 mpn/100ml	908(8)	30hr
Radium-226 (6)	0.05pCi/l	706(8)	6mo
Gross Alpha (6)	3.0 pCi/l	703(8)	6mo
Gross Beta (6)	0.1pCi/l	703	6mo
Endrin (5,7)	0.0001	509(8)	7d
Lindane (5,7)	0.001	509	7d
Methoxychlor (5,7)	0.001	509	7d
Toxaphene (5,7)	0.001	509	7d
2,4-D(5,7)	0.001	509	
2,4,5-TP Silvex (5,7)	0.001	509	
Phenols (Phenolics, Total Recoverable) (5,7)	0.005	420.2	28d
Orthophosphate as P	0.02	365.3	
Silica as SiO2	10.0	370.2	
Nickel	0.04	249.1	6mo
Hardness	10.0	130.1	
Acidity	±10.	Technicon method	14 days

Parameter	Detection Limit (1)	EPA (10/26/84) Method No.	Maximum Hold Time
Temperature	1.	170.1	
Total Organic Carbon (TOC)[4]	.01	415.2	28d
Total Organic Halogen (TOX)[5,7]	.25	9020(2)	

Footnotes:

(1) All units in mg/l unless otherwise noted.

(2) EPA, 1982, Test Methods For Evaluating Solid Waste: EPA SW-846, July 1982.

(3) These parameters will be measured in the field.

(4) Coliform shall, after Round 1 sampling, only be monitored at sites: S-200, 238, 352, 21B; K-84, 100, 201; P-207a, 207b, 208a, 208b; W-41a, 189, 300, 301, 309, 310, 311, 312, 329, 333, 348 (As agreed to by the Technical and Advisory Groups since Round 1 sampling showed insignificant concentrations and the fact that Kennecott's contaminants do not include these parameters).

(5) Analysis for organics, phenols TOC and TOX were deleted after Round 1 analytical result evaluations by the Technical and Advisory Groups because of insignificant concentrations, and the fact that Kennecott's contaminants do not include these parameters.

(6) Radionuclides will be analyzed by CEP Laboratory, Santa Fe, New Mexico, which is EPA certified for such analysis.

(7) Will be analyzed by Kennecott's laboratory, Salt Lake City.

(8) APHA-AWWA-WPCI, 1981, Standard Methods for Examination of Water and Wastewater: American Public Health Association, 15th ed.

(9) Temperature reported in °C.

NOTE: Metals concentrations have been determined on a "dissolved" basis. Total metals concentrations are available and have been analyzed since Round 1 (1983-1984) sampling. This has been conducted as part of Kennecott's quality assurance.

5.0 SAMPLING PROCEDURES

5.1 SAMPLE SITES

New ground-water monitoring well locations (Phase I drilling) and construction are as specified in Reference 9, attached, as per Reference 10 and as agreed upon by the Ground-Water Technical and Advisory Group members from Kennecott, the Utah Department of Health and Salt Lake County Flood Control and Water Quality. Well construction materials shall be either PVC, galvanized or stainless steel and shall be properly grouted to monitor specific zones, as detailed in Reference 9.

New monitor well construction, design and sampling have been designed as per the objectives of Reference 10 and as per approval by the Technical and Advisory Groups (appropriate government officials, page 13, Reference 10).

Specifically, as per Reference 10:

1. The drilling methods to be used will: a. accomplish the job and b. not introduce contamination or significant disturbance into the formation monitored. The preferred drilling methods are, in order: 1. Air Hammer, 2. Cable Tool, 3. Air Rotary. Mud Rotary drilling will be considered as a last resort. Validity will be demonstrated by field conductivity measurements during and after well development, visual observation of the quality of the well waters during surging and laboratory measurement of suspended solids.

2. NSF approved PVC and/or 316 stainless steel casings (and/or other suitable pipe above the water table in areas of noncontaminared waters where casing materials will be non-reactive) shall be used since Kennecott does not have organic contaminants (i.e. phthalate or vinyl chloride from PVC).

3. Gravel pack will be clean Colorado silica sand and will only extend above the screen far enough (at the most 20 to 40 feet) to ensure that a water sample can be obtained, and to limit the vertical sample area to a permeable zone, and a bentonite seal shall be placed above the pack and the remainder of the annular space shall be tremied with a cement or grout mixture.

4. Wells shall be developed to produce as turbid-free water as possible.

5. Wells shall be screened over as small a zone as practicable.

6. Well diameters shall be 4 inches I.D.

7. Wells shall be sampled with a state approved submersible pump, since organic contaminants are not present.

Existing (pre-1984) ground-water monitor well locations and construction were installed prior to the start of the 5-year Ground-Water Study. Data on these wells are included in reference 1. Pre-1984 Kennecott monitor wells are constructed out of PVC or steel casing. Private water wells are generally constructed out of steel casing. Data from these wells will be used in conjunction with data from new QA'ed wells. Additional drilling and sampling may be required if data from existing wells are in conflict with data from new QA'ed wells.

Phase II ground-water monitoring well locations and construction, scheduled for 1986, have not been specified. These well will also be approved by the Technical Group prior to construction, and will be located to monitor the ground-water quality near those Kennecott facilities which are contributing to ground-water contamination. Determination of the locations and depths will be heavily dependent on the ground-water quality data obtained from the Phase I monitor wells.

5.2 SAMPLE COLLECTION

Prior to sampling, the wells will be purged with a submersible pump or a bailer. A minimum of three casing volumes and a maximum of five casing volumes will be purged before sample collection. The volume will be consistent per well as sampling dictates. The volumes will be computed based on the equation $(\pi r^2 h)/7.48$ gallons, where r(ft) is the well radius, h(ft) is the distance from the static water level to the well bottom. This volume is multiplied by 3 or 5, depending on the number of casing volumes to be removed. The volumes pumped will be measured using a 5 gallon bucket and stop watch. However, for the older Kennecott monitor wells constructed of steel pipe which intercept low pH waters, in order to clean the well thoroughly, 10 casing volumes maximum may be taken out prior to sampling (Reference 10). The submersible pump and intake hose shall be thoroughly cleaned between well sample sites by flushing the pump and hose via pumping for at least 30 minutes (with waters of drinking water quality) or until the pH and conductivity levels stabilize to approximately 7 pH units and 1000 umhos/cm. A transfer blank shall be run periodically to ensure proper cleansing of the pump.

For each sample, the form given in Table 5-1 should be filled out completely. Each sample for laboratory analysis will be placed in a series of containers, with the appropriate preservatives as summarized in Table 5-1.

Sample containers should be placed out of direct sunlight, preserved, shipped and analyzed within the maximum allowable hold times as specified in Table 4-1. The preservation methods indicated conform to the requirements of Reference 4. Samples should be shipped to the laboratory as soon as possible, preferably the same day as collection. These methods call for the use of various specific type containers, addition of preserving agents, refrigeration (certain sample bottles should be immediately placed and shipped on ice), and be analyzed by the laboratory within the maximum hold times.

Blank and duplicate samples will also be taken in the field as outlined in Section 10.0.

Sample labels, field sampling and analysis records, and chain-of-custody records will be prepared as outlined in Section 6.0.

During the sampling, static water level, pH, specific conductance, temperature, carbonate and bicarbonate measurements will be made at each site and recorded on the form shown on Table 5-1. Measurements will be made in small sample containers. The meters used to measure pH and conductivity and procedures used for calibration are outlined in Section 7.0.

ph meter I.D. number______

TABLE 5-1. UCD HYDROLOGIC STUDY FIELD WATER QUALITY DATA SHEET

Conductivity meter I.D. number______

Sample Site Designation	Time and Date	Pre-Pumping Depth to Water From Top of Casing (Tenths of Feet)	Initial Conductivity umhos/cm	Final Conductivity umhos/cm At Sample (1) Collection	Temp. °C	Well Volumes Removed	ph	Carbonate CO_3 mg/l	Bicarbonate HCO_3 mg/l	Miscellaneous Information (i.e. visual description of well and water)	Well Owner & Address	Weathe

Check Samples Collected Ref. No.		Container and Preservative
1.	______	2 liters, unfiltered, acidified HNO_3 to pH 2, into a plastic container
2.	______	2 liters, filtered with .45 micron filter paper, acidified HNO_3 to pH 2, into a plastic container
3.	______	2 liters, unfiltered, cool 4°C, plastic container
4.	______	100 ml, unfiltered, acidified H_2SO_4 to pH 2, into a plastic container
5.	______	1 liter, unfiltered, cool 4°C, pH 5-9, full to top in a glass bottle with a teflon lid
6.	______	1 liter, unfiltered, cool 4°C, pH 5-9, full to top in a glass bottle with a teflon lid
7.	______	2 liters, unfiltered, acidified with H_2SO_4, pH 2, in a glass bottle with a teflon lid
8.	______	4 ounces, unfiltered, cool 4°C, into a sterilized glass bottle (avoid body contact with sample)
9.	______	1 liter, unfiltered, acidified with HNO_3, pH 2, into a glass bottle
10.	______	40 ml, unfiltered, preserved with $Na_2S_2O_3$, into a glass bottle full to top with teflon lid

Parameters For Analysis:

1. For Total Metals
2. For Dissolved Metals
3. For F, CO3, HCO3, AlK, Cl, SO4, pH, SC, TDS, TSS, Ca, P, Temp, Na, SiO2, K
4. For Nitrate
5. For Herbicides
6. For Pesticides
7. For Phenolics
8. For Coliform
9. For Radionuclides
10. For TOX

All sample bottles shall be labeled with:

Site Name:
Date:
Preservative:
Filtered: ______ /Unfiltered: ________
Sampler's Name: ____________________

6.0 SAMPLE CUSTODY

6.1 FIELD OPERATIONS

An essential part of the sample collection activity is the documentation of site measurements and the ensuring of the integrity of the sample from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the history of the sample is referred to as chain-of-custody. The following records and actions will be taken.

1. Sample Labels - Sample labels are necessary to prevent misidentification of samples. The sample label shown on Table 6-1 should be completely filled out and attached to the sample at the time of collection.

2. Field Sampling and Analysis Record - Pertinent field measurements and observations should be recorded. To facilitate these records the form shown on Table 5-1 should be filled out for each sample. Documentation of the sources of buffers, standards, reagents, sample containers, etc., should be recorded on the reverse side of the form shown on Table 5-1.

3. Chain-of-Custody Record - To establish the documentation necessary to trace sample possession from the time of collection, the chain-of-custody record as shown in Table 6-2a should be filled out to accompany every sample shipment from the time of collection through receipt by the analytical laboratory. The sample should be delivered to the laboratory for analysis as soon as possible, usually within one day after sampling. Maximum hold times are shown in Table 4-1.

   The date of sample laboratory logging is shown by the Julian date, the analytical control number and the date of field sampling are indicated in the upper right hand corner. An example sheet is included (Table 6-2b). The types of analyses conducted are indicated by the codes on the "Master Sheet Guide" (Table 6.2c) which the field sheet specifies.

TABLE 6-1

SAMPLE LABEL

PROJECT: UCD 490088

SITE NAME: ____

DATE: ____

PRESERVATIVE: ____

FILTERED: ______________ UNFILTERED: ____________________

SAMPLER'S NAME: ____

6.2 LABORATORY OPERATIONS

The laboratories used will be State of Utah or EPA certified. The QA document for CEP laboratory has been submitted to the State for approval. The laboratories will maintain internal chain-of-custody control in accordance with their own standard quality assurance program.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

7.1 GENERAL

Meters used to measure pH and specific conductance will be calibrated as outlined below prior to and during use. Source and identification (lot number, etc.) of standards used to calibrate will be recorded; identification numbers of the instruments used will also be recorded.

7.2 FIELD pH

Field pH is to be performed with one of the following, or an equivalent instrument, which are automatically corrected to a temperature of 25°C.

Manufacturer	Model No.	Serial No.
Fisher	805MT	2937
Orion Research	211 Digital	214694
Orion Research	407A	3620

Follow manufacturer's instructions for operation and standardization of instruments. Perform two-buffer standardization with buffers approximately 3 pH units apart and spanning the anticipated measurement values prior to first use and before each measurement where occasional pH measurements are made. Where frequent measurements are made, less frequent standardization (every 1 or 2 hours) is satisfactory. However, if sample pH values vary widely, standardization will be more frequent.

Standardization and measurement procedures should be in accordance with those contained in References 3 and 4.

Notes:

1. If oil gets on the electrodes, clean the electrodes with acetone or hydrochloric acid (1 to 9), as necessary.

2. Store pH electrode in pH 7 buffer.

7.3 FIELD SPECIFIC CONDUCTANCE

Field specific conductance measurements are to be done with the following, or equivalent instrumentation:

Manufacturer	Model No.	Serial No.
Yellowsprings (YSI)	33	9042

Specific conductances are corrected to 25°C for computer printout results. Wet standardization methods (KCL standard solution) as per manufacturer's instructions, are to be used. Calibration is to be done before each sample site measurement.

7.4 TEMPERATURE

Temperature should be measured using a good grade ASTM temperature certified thermometer. Temperature should be reported to the nearest 1°C.

7.5 WATER LEVEL METERS

Electric water level meters will be calibrated prior to use, with 5-foot tape measurements to verify the footage intervals, prior to the start of the annual sampling program.

7.6 WATER LEVEL MEASUREMENTS

Static water level measurements will be measured from the top of the well casing (at the same marked point each time), prior to well water sampling. Water levels will be measured to the nearest .01 foot using the electric water level meter and a steel tape, calibrated in tenths and hundredths of feet.

All Kennecott monitor wells have steel caps with locks to prevent any well tampering between sampling rounds.

8.0 ANALYTICAL PROCEDURES

Analytical procedures to be used are listed in Table 4-1.

9.0 DATA REDUCTION, VALIDATION AND REPORTING

Analytical results will be reviewed on the original laboratory certificates of analysis. The laboratory will calculate and report an ion balance for waters which are not significantly contaminated (i.e. less than 1500 mg/l TDS) based upon major constituents for each sample. Reported concentrations and ion balances will be reviewed. Unusually large or small concentrations will be identified and reanalysis ordered. Outliers will be identified based upon ion balances, comparisons with other samples, and results of internal quality control checks (Section 10.0). Original laboratory certificates of analysis will be used to report analytical results. Key individuals and responsibilities are given in Section 3.0.

10.0 INTERNAL QUALITY CONTROL CHECKS

10.1 FIELD OPERATIONS

Blind field duplicates will be prepared and submitted to the laboratory by Kennecott personnel. One out of every 10 samples will be blind field duplicates. Splitting for duplications will be done by pumping waters and simultaneously filling sample containers. The Technical Group agreed that the Salt Lake County Health Department will split samples on a frequency of one full day of sampling per month, and that the county laboratory will analyze those parameters that they are certified to analyze for. The County will submit a QA document to the State for approval.

Five percent field blanks will be collected per annual sample round. The blank sample will consist of distilled water poured into sample containers.

10.2 LABORATORY OPERATIONS

The laboratory will conduct its own internal quality control checks in accordance with its own QA program as a part of State certification. This will include running at least 10 percent duplicate, spike and control samples. The laboratory will summarize the results of these quality control checks and submit them with the analytical results as part of the semi-annual quality assurance reports.

11.0 PERFORMANCE AND SYSTEM AUDITS

The results of all analyses and quality control checks will be reviewed by the Kennecott laboratory prior to computer input. Existing regulatory performance audits (i.e. state and federal will be provided for each round of sampling and included in each yearly report) will be carried out after each round of sampling and a written report prepared after the round is completed as outlined in Section 15.0.

12.0 PREVENTIVE MAINTENANCE

Conductance and pH meters and probes will be cleaned with acetone or hydrochloric acid (1 to 9) as necessary and rinsed with distilled water and checked after each sampling period and any problems reported to the technical manager and recorded on the field sheets.

Laboratory equipment maintenance will be followed as per the Laboratory QA/EPA certified plan.

13.0 PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY AND COMPLETENESS

Data generated during ground-water sample collection will be evaluated qualitatively based on the extent to which procedures were followed, instrument performance and other factors. The precision, accuracy, and completeness of the analyses of quality control samples will be assessed using the procedures described in this section. The laboratory will provide the technical manager with their analytical control limits.

Quality control samples will consist of field blanks and blind duplicate ground-water samples. The field blanks and blind samples will verify the absence of field contamination and analytical precision. The standard deviation and mean of all the recovery percentages will be calculated for each parameter.

Satisfactory limits for precision, accuracy and completeness will be judged with respect to the QA objectives given in Section 4.0.

14.0 CORRECTIVE ACTION

Corrective action will be undertaken if sample collection deficiencies or unreliable analytical results prevent QA objectives for the project from being met. The criteria for acceptable sample collection data are given in Section 5.0 and the laboratory's QA program provides the criteria for acceptable analytical results.

Analytical results supplied by the laboratory will have been subjected to the laboratory's QA plan and will be considered by the Technical Group to be acceptable unless the results significantly contradict prior knowledge of the site conditions. When this situation occurs, the Technical Group will request that the laboratory review the quality control documentation for the sample or analysis in question. Further corrective action will be based on the specific details of the situation.

The principal corrective action that may be required as a result of deficiencies in sample collection is resampling if one or more of the following problems occur:

1. Gross contamination due to sample collection errors rendering the entire sample useless.

2. Wide variation between duplicate analyses of a parameter.

3. Loss of a sample in transit to or in the laboratory.

4. Violation of holding times for particular, especially critical, parameters.

Because over 150 water samples will be collected each year, resampling will be required only if corrective action is necessary. Reanalysis may be substituted for resampling if the holding time has not expired and the sample condition is satisfactory.

A request for corrective action may be initiated by the project manager or the technical group, but final approval for major corrective action must come from the Advisory Group.

15.0 QA REPORTS

A QA report will be prepared following the completion of the annual sampling period when the laboratory analyses are available. Specifically, the report will address the following areas:

- Results of system and/or performance audits of sample collection activities.

- Summary of the laboratory QA report.

- Listing and basis for any unacceptable data.

- Significant QA problems and recommended solutions.

The QA report will be prepared by the Laboratory Manager and Technical Manager and Technical Group. The final report for the project will contain a QA section which will summarize the data quality information, to include a discussion of QA discrepancies and a list of corrective actions.

16.0 REFERENCES

1. Kennecott, with input and approval by the Utah Ground-Water Technical and Advisory Groups, June, 1984, Report I, Geologic, Ground And Surface Water Data Background And Progress Report Of Kennecott's UCD Mine Hydrogeologic Study.

2. Dames and Moore, Kennecott, with input and approval by the Utah Ground-Water Technical and Advisory Groups October, 1984, Environmental Assessment Status Report for Kennecott's UCD Mine Hydrogeologic Study.

3. EPA, 1983, Characterization of Hazardous Waste Sites - A Methods Manual, Volume II. Available Sampling Methods: EPA-600/4-83-040.

4. EPA, 1982a, Test Methods-Technical Additions to Methods for Chemical Analysis of Waters and Wastes: EPA-600/4-82-055.

5. EPA, 1979, Handbook For Analytical Quality Control For Water Laboratories: EPA 600/4-79-019, March 1979.

6. EPA, 1982, Handbook For Sampling and Sample Preservation of Water and Wastewater.

7. EPA, 1979, Methods For Chemical Analysis of Water and Wastes: EPA-600-4-79-020.

8. EPA, 1982b, Test Methods For Evaluating Solid Waste, Physical/Chemical Methods: EPA SW-846, 2nd Edition.

9. Phase I Monitoring Well Construction Specifications For Utah Copper Division, Kennecott, March, 1985.

10. EPA, 1985, Draft Chapter 3 to SW-846.

PHASE I MONITORING WELL CONSTRUCTION SPECIFICATIONS

FOR

UTAH COPPER DIVISION

KENNECOTT CORPORATION

JUNE 1985

Prepared By

DAMES & MOORE
250 East Broadway - Suite 200
Salt lake City, Utah 84111

SCHEDULE OF CHARGES
INSTALLATION OF GROUND WATER MONITORING WELLS
FOR UTAH COPPER DIVISION
KENNECOTT CORPORATION

Item	Description	Estimated Quantity	Unit Price	Total Price
1	Mobilization-Demobilization	1	Lump Sum	$______
2	Set-up	27 ea	$____/ea	$______
	COMPLETED WELLS WITH DEPTHS RANGING BETWEEN 0 AND 200 FEET			
	WELL CONSTRUCTION			
3	Drilling	1,015 ft	$____/ft	$______
4	Geophysical Logging Standby-Time	8 hrs	$____/hr	$______
5	Ground Water Sampling During Drilling	16 hrs	$____/hr	$______
6	Provide and Install Grout for Grouting Back Boring	0 ft	$____/ft	$______
7	Provide and Install Screen	390 ft	$____/ft	$______
8	Provide and Install Casing	625 ft	$____/ft	$______
9	Provide and Install Sand Pack	470 ft	$____/ft	$______
10	Provide and Install Grout Seal	545 ft	$____/ft	$______
11	Provide and Install Surface Completion	8 ea	$____/ea	$______
12	Well Development	8 ea	$____/ea	$______
	COMPLETED WELLS WITH DEPTHS RANGING BETWEEN 200 AND 600 FEET			
	WELL CONSTRUCTION			
13	Drilling	5,700 ft	$____/ft	$______
14	Geophysical Logging Standby-Time	8 hrs	$____/hr	$______
15	Ground Water Sampling During Drilling	60 hrs	$____/hr	$______
16	Provide and Install Grout for Grouting Back Boring	0 ft	$____/ft	$______
17	Provide and Install Screen	710 ft	$____/ft	$______

Item	Description	Estimated Quantity	Unit Price	Total Price
COMPLETED WELLS WITH DEPTHS RANGING BETWEEN 200 AND 600 FEET				
18	Provide and Install Casing	4,990 ft	$______/ft	$__________
19	Provide and Install Sand Pack	860 ft	$______/ft	$__________
20	Provide and Install Grout Seal	4,840 ft	$______/ft	$__________
21	Additional Grout Pours	15 ea	$______/ea	$__________
22	Provide and Install Surface Completion	19 ea	$______/ea	$__________
23	Well Development	19 ea	$______/ea	$__________
STANDBY TIME				
24	Standby Time	0 hrs	$______/hr	$__________
EXTRA WORK				
25	Drilling Equipment	0 hrs	$______/hr	$_________
26	Drilling Crew Number of Men in Crew ____	0 hrs	$______/hr	$_________
			Subtotal	$_________
			Total	$_________

Description of drilling rig(s) to be used:

Type: ____

Make: ____

Model: ____

Size of Drill Pipe: ________________________________

Number of Wheels: __________________________________

Number of Drive Wheels: ____________________________

Capacity Water Truck: ______________________________

Normal Crew (# of men): ____________________________

Years Experience of Driller: _______________________

Air Compressor Capability: __________ cfm @ ___________ psi

Preferred Starting Date: ___________________________

Calendar Days to Complete: _________________________

The work under this Agreement will be started by Drilling Contractor within fourteen (14) calendar days after receiving Contractor's Notice to Proceed and will, unless delayed by circumstances beyond Drilling Contractor's control, be completed by _________________________. This completion contemplates, but is not limited to, a working schedule of five days per week and one 8-hour shift per day.

Contractor shall make progress payments and final payment to Drilling Contractor in the manner and at the times stated in the General Section.

TECHNICAL SPECIFICATIONS

FOR CONSTRUCTION OF MONITORING WELLS

SECTION 4.0

TECHNICAL SPECIFICATIONS
FOR CONSTRUCTION OF MONITORING WELLS
SECTION 4.0

4.1 PROJECT DESCRIPTION

4.1.1 GENERAL - These specifications describe the construction of monitoring wells near Kennecott Corporation's Utah Copper Division mining operations in Salt Lake County, Utah. Twenty-seven 4-inch diameter monitor ing wells are to be installed as part of Kennecott Corporation's monitoring well system. These new wells will range in depth from approximately 50 to 500 feet and are being installed to define the subsurface geology and to monitor water levels and the water quality. Total footage of installed wells is estimated to be around 7,000 feet.

4.1.2 SCOPE OF WORK - The work is to be comprised of the complete drilling; cutting sample collection; water sample collection; standby during geophysical logging; procuring and installing complete screen and casing assembly; sand packing and grouting; well development; procuring and installing protective covers and marker posts; providing driller's logs and daily logs; and completing other work as needed for the construction of these monitoring wells. Owner will stake locations, construct access roads, and provide all required surveying services. A schematic illustration of the proposed well construction is shown on Plate 1.

Severe restrictions shall be imposed upon the introduction of drilling fluids or foreign materials into the well borings in order to protect ground water quality during drilling and following well completion. Mud-rotary techniques shall not be allowed. No drilling fluid additives shall be allowed unless approved in advance in writing by the Engineer. The use of drilling additives will be discouraged and will not be approved unless it is shown that the additives will not significantly affect water quality, even at trace levels. The use of clean water in small amounts may be approved by the Engineer if obtained from a potable water source. Contractor shall take all reasonable precautions to prevent the entrance of oils, grease, and other contaminants from entering the borings through his equipment, materials and actions.

4.1.3 CONTRACTOR - is to supply all equipment, materials and labor necessary to complete these wells. Contractor shall remain on site until the completion of all work. Termination of the work shall be at the direction of the Engineer or Owner.

4.1.4 DEPTHS - Due to the wide range of anticipated well depths, the construction methods used to complete the wells will vary as a function of the well depth. For this reason, the wells are categorized on the basis of well depth into the following groups: 0-200 feet, 200-600. When necessary the specifications will differentiate between materials and construction techniques used to install wells within these categories. When not explicitly stated, Contractor should assume that there is no significant difference in the construction materials or techniques used to complete these wells.

4.1.5 LOCATION - The proposed monitoring wells are located near Kennecott Corporation's Utah Copper Division mining operations in Salt Lake County. The specific locations of the proposed monitoring well sites will be specified by Engineer. Approximate well locations are shown on Plate 2. Engineer will specify the order in which the wells shall be constructed.

4.1.6 PLANS AND WORKING DRAWINGS - Plans included with the specifications are complete and adequate for construction. While every effort has been made to have the plans free of errors and ambiguities, any such points must be brought to the Engineer's attention prior to contract award.

4.1.7 SITE ACCESS - The Contractor shall obtain all necessary permits and/or permission to utilize public or private roads. The Owner will provide reasonable access to all drill sites and when access to the site requires the use of private rights-of-way the Owner shall obtain the required approvals, permits and/or permission. The Contractor shall confine his apparatus, storage of materials, and operation of his workmen to the limits indicated by law, ordinance, permits or direction of the Engineer and/or Owner, and shall not unreasonably encumber the premises with his materials. Contractor shall, at all times, keep the site free from accumulations of waste materials or rubbish resulting from his work.

4.1.8 MATERIALS FURNISHED BY CONTRACTOR - If Contractor proposed equivalent material or equipment, Contractor must submit information data to the Engineer in written form to prove such equivalence. The information shall consist of drawings, specifications, catalogs, etc., as applicable. The proposed material must be approved by the Engineer before proceeding with purchase, production or manufacture of any material. Engineer must be allowed reasonable review time prior to his approval or denial of this request.

4.1.9 REQUEST FOR VARIANCES FROM THE PLANS AND SPECIFICATIONS - In the event that Contractor may wish to deviate, vary or otherwise alter the design or method of construction of the wells or the installation of pumps, he shall make a formal request to the Engineer. This request must be in writing, with whatever drawings, calculations, costs and other information that will be needed by the Engineer to evaluate this request. The Engineer must be allowed reasonable review time prior to his approval or denial of this request.

4.1.10 CORRESPONDENCE FROM CONTRACTOR - All correspondence from the Contractor to the Engineer shall be submitted to Dames & Moore, 250 East Broadway, Suite 200, Salt Lake City, Utah 84111, Attention: Mr. George W. Condrat.

4.1.11 TIME TO COMPLETE - The number of days for performance allowed herein is based on the original quantities as defined in the Agreement. If satisfactory fulfillment of the contract requires performance of work in substantially greater quantities than those set forth in the Agreement, the contract time allowed for performance may be increased on a basis commensurate with the amount and difficulty of the added work after written request by the Contractor.

4.1.11.1 EXTENTION OF TIME TO COMPLETE - If the Contractor finds it impossible for reasons beyond his control to complete the work within the contract time as specified or as extended, he may, at any time prior to the expiration of the contract time, make a written request to the Engineer for an extension of time, setting forth therein the reasons which he believes will justify the granting of his request. If the Engineer finds that the work was delayed because of conditions beyond the control and without the fault of the Contractor, he may extend the time for completion in such amount as the conditions justify. The extended time for completion shall then be in full force and effect the same as though it were the original time for completion.

4.1.11.2 FAILURE TO COMPLETE WORK ON TIME - If the Contractor refuses or fails to complete the contract work within the specified time guaranteed in the Agreement, plus any extensions authorized by the Engineer, a daily charge will be made against the Contractor for each calendar day that any work shall remain uncompleted after elapse of the guaranteed completion time plus extensions, if any. This charge will not be considered a penalty, but as liquidated damages for delay. The daily charge will be $1,000 per calendar day. This paragraph shall not be construed as limiting Owner's rights at law or in equity to recover any damages or enforce specific performance of this contract.

4.2 TECHNICAL SPECIFICATIONS

4.2.1 MATERIALS

4.2.1.1 CASING - The type of casing used shall be dependent on the well depth.

4.2.1.1.1 Casing For Well Depths Between 0 and 200 Feet.

- The casing shall be constructed using 4-inch diameter NSF (National Sanitation Foundation) approved PVC Schedule 40 plastic pipe. All couplings and adapters shall also be NSF approved PVC Schedule 40 plastic. All couplings and/or adapters shall be joined to the pipe (or screen) using mechanical screw joints. Casing joints shall also be mechanical screw joints rated for differential pressures through the joint in excess of 50 psi with no leakage. The use of solvents, glues and/or other adhesives will not be allowed. The use of pipe dope or other pipe joining compounds is also prohibited. The use of gaskets and/or other types of seals must be approved by the Engineer.

4.2.1.1.2 Casing For Well Depths Between 200 and 600 Feet.
- The casing shall be constructed using 4-inch diameter NSF (National Sanitation Foundation) approved PVC Schedule 80 plastic pipe. All couplings and adapters used shall also be NSF approved PVC Schedule 80 plastic. All couplings and/or adapters shall be joined to the pipe (or screen) using mechanical screw joints. Casing joints shall also be mechanical screw joints rated for differential pressures through the joint in excess of 50 psi with no leakage. The use of solvents, glues, and/or other adhesives will not be allowed. The use of pipe dope or other pipe joining compounds is also prohibited. The use of gaskets and/or other types of seals must be approved by the Engineer.

4.2.1.2 SCREEN - The type of screen used shall be dependent on the well depth. All screens shall have centralizers installed at their base and top to ensure that the screen will be centered within the diameter of the boring.

4.2.1.2.1 Screens For Well Depths Between 0 and 200 Feet.
- The screens shall be commercially fabricated using NSF approved PVC Schedule 40 plastic pipe. The pipe shall be slotted with saw-cut slots 0.018 by 1.0 inches with a least 40 slots per row per foot. There shall be a minimum of six rows of slots. A suitable slotted PVC screen is available from Hydrophilic Industries, Puyallup, Washington. Maximum allowable slot tolerance shall be +-0.005 inches. All screen joints shall be mechanical screw joints. No glue or other adhesives shall be used to form the joint.

4.2.1.2.2 Screens For Well Depths Between 200 and 600 Feet.
- The screens shall be commercially fabricated using NSF approved PVC Schedule 80 plastic pipe. The pipe shall be slotted with saw-cuts 0.018 by 1.0 inches with at least 40 slots per row per foot. There shall be a minimum of six rows of slots. A suitable slotted PVC screen is available from Aardvark Industries, Puyallup, Washington. Maximum allowable slot tolerance shall be +-0.005 inches. All screen joints shall be mechanical screw joints. No glue or other adhesives shall be used to form the joint.

4.2.1.3 SAND PACK - Materials used for the sand pack shall be a clean washed sand containing less than 5% deleterious material by weight and shall conform to the following gradation limits:

U.S. Standard Sieve Size	Permissible Range Passing (in percent)
#12	100 - 95
#16	100 - 80
#20	90 - 20
#30	40 - 5
#40	10 - 0

Deleterious materials are considered to be wood debris, other organic matter, heterogeneous material and degradable materials. A sand pack meeting these specifications is available from Colorado Silica Sand, Pueblo, Colorado.

4.2.1.4 GROUT MIXTURE - The grout shall be a neat cement grout consisting of a mixture of Portland cement, four pounds of bentonite per bag of cement (one cubic foot or 94 pounds), and not more than eight gallons of water per bag of cement. Bentonite slurry shall be mixed prior to adding cement.

4.2.1.5 PROTECTIVE WELL COVERS - Protective well covers shall be fabricated using 10-inch diameter galvanized steel pipe having a minimum wall thickness of 0.25 inches, and a 0.25-inch thick steel cover. The cover shall be tight fitting. The design of the protective casing and cap is shown on Plate 1. The protective covers shall be painted, using proper primers and high quality oil-based paints, prior to their installation. A durable case-hardened steel lock will be provided by the Contractor to lock the protective casing. All locks shall be keyed alike. The color of the exterior coat of paint shall be as specified by the Owner. Other protective cover arrangements may be allowed if approved by the Engineer.

4.2.1.6 WELL LOCATION MARKER POSTS - The well location marker posts shall consist of a 2-inch diameter steel pipe approximately 8 feet long. The minimum wall thickness of the pipe shall be 0.154 inches. The pipe shall be painted using proper primers and a high quality oil based paint. The color of the exterior coat of paint shall be as specified by the Owner.

4.2.1.7 PVC PIPE AND FITTINGS - Pipe and fittings shall be of NSF (National Sanitation Foundation) approved Type I PVC. Pipe shall conform to ASTM Standard D2241 (ASTM 1785 for Schedule 40 or Schedule 80).

4.2.2 CONSTRUCTION OF MONITORING WELLS

The monitoring wells are to be constructed at the locations designated by the Owner. The locations will be marked and staked by the Owner. The Engineer will specify, in writing, the screen length and setting after completion of the geophysical logging of the test hole.

4.2.2.1 EXCAVATIONS - No excavations other than those detailed in these plans and specifications may be made without the written consent of the Engineer.

4.2.2.2 DRILLING - Contractor shall construct a boring having a minimum nominal diameter of eight inches. The boring shall be constructed to the depths specified by the Engineer. Care shall be taken to make the hole as straight and plumb as possible. The hole must be clean and stable to allow completion of the well at the prescribed depths. Since the use of drilling muds shall not be allowed, Contractor may wish to use temporary steel casing during drilling. Unless otherwise approved in writing by the Engineer, steel casing (other than protective well covers) shall be completely removed from the boring during well completion.

If temporary casing is used during drilling, the temporary casing shall be removed in a manner so as to prevent breakage of the PVC casing and screen, and so as to ensure that the sand pack and grout completely surround the screen/casing assembly as shown on Plate 1. This may require that sand pack and grout are installed as the temporary casing is withdrawn.

4.2.2.2.1 Drilling Methods - Contractor may construct the boring using cable-tool, air-hammer, air-rotary or other drilling methods reasonably capable of constructing a relatively clean, stable hole to the prescribed depth within a reasonable time span.

Severe restrictions shall be imposed upon the introduction of drilling fluids or foreign materials into the well borings in order to protect ground water quality during drilling and following well completion. Mud-rotary techniques shall not be allowed. No drilling fluid additives shall be allowed unless approved in advance in writing by the Engineer. The use of drilling additives will be discouraged and will not be approved unless it is shown that the additives will not significantly affect water quality, even at trace levels. The use of clean water in small amounts may be approved by the Engineer if obtained from a potable water source.

4.2.2.3 SEDIMENT SAMPLING - Sediment samples are to be collected at 5-foot intervals and at any depth where a significant change in the drilling characteristic is noted. The samples shall be collected in such a manner as to be reasonably representative of the unit being drilled. All samples shall be properly labeled, placed in a suitable container and given to the Engineer.

4.2.2.4 GROUND WATER SAMPLING DURING DRILLING - If requested by the Engineer during the course of drilling operations, the Contractor shall efficiently bail water from the boring in order to obtain a representative ground water sample. Contractor shall provide and use a bailer made of

NSF approved PVC if so requested by the Engineer. The Engineer shall specify the length of time the boring is to be bailed. The Contractor shall then fill bottles supplied by the Engineer with a representative ground water sample. The Contractor shall accurately measure the depth to ground water in the boring if so requested by the Engineer.

4.2.2.5 DRILLER'S LOGS - During the drilling of the boring Contractor shall prepare and keep a complete drilling log. This log should include as a minimum:

1) The depths at which changes in soil types are noticed.

2) A brief description of each soil type encountered.

3) The depth of each occurrence of water.

The driller's log is to be given to the Engineer upon completion of the monitoring well.

Engineer will be on site from time to time to monitor and inspect the drilling and installation of the well. Contractor shall provide the Engineer with any relevant data, and/or samples requested by the Engineer. While the Engineer will prepare his own report, the driller's log shall be prepared and submitted as an independent document.

4.2.2.6 ESTIMATED DRILLING CONDITIONS - Boreholes will be drilled into three hydrologic units: Quaternary sediments, Tertiary sediments, and Tertiary volcanics. Table 1 lists the anticipated well depths and Plate 2 shows the proposed monitoring well locations.

4.2.2.6.1 Quaternary Sediment - These sediments include lacustrine, deltaic, alluvial, and colluvial deposits that range in thickness from less than a foot near the mountains to over 1,000 feet in the center of the valley. Texturally these sediments range from clays to coarse gravels. In general, the coarser-grained textures are more prevalent near the mountain front.

4.2.2.6.2 Tertiary Sediments - Texturally these sediments range from clays to coarse gravels and are composed of various types of sedimentary deposits, including mud flow, deltaic, colluvial, and alluvial sediments. The Tertiary sediments are generally more consolidated than Quaternary sediments and are frequently cemented.

4.2.2.6.3 Tertiary Volcanics - These units are found both exposed on the surface and overlain by colluvial and alluvial sediments. The volcanics generally consist of rhyolite, andesite and latite flows, agglomerates, tuffs and breccias.

4.2.2.6.4 Disclaimer - Subsurface information cited above is presented solely for the convenience of the Contractor as an aid to identifying and evaluating suitable materials in the field during construction of the facilities described herein. Neither Owner nor Engineer represents that the subsurface information presented shows conditions that will be encountered in performing the work. Contractor must assume all responsibilities for conclusions which may be made as to the nature of the materials encountered, and the difficulties of making and maintaining the required borings and of other work affected by the geology of the site.

4.2.2.7 GEOPHYSICAL LOGGING - The Engineer may direct that a borehole be geophysically logged following its completion. Owner shall provide the geophysical logging services. Contractor shall aid the Engineer in obtaining these logs and shall warrant that the boring is clean and stable.

4.2.2.8 GROUTING BACK BORING - Engineer may require that a portion of the boring be grouted back. In the event grouting back is required, Engineer will furnish Contractor the depth to which the boring is to be grouted. Grout shall be allowed sufficient time to set prior to sand packing this well.

4.2.2.8.1 Tremieing Grout - The grout must be tremied to within five feet of the bottom of the boring. The tremied pipe shall be kept at all times within the grout while the grout is being introduced.

4.2.2.9 PITS - If excavated pits are required, the pits shall be excavated by the Contractor. Contractor shall provide the Engineer, for his approval, detailed drawings of the pits specifying the required shape, length, and depth at least 72 hours prior to the start of drilling activities at the specified well location. Excavated pit designs shall not be elaborate nor require more than the necessary volume of excavation.

4.2.2.10 DAILY DRILLER'S REPORT - During the drilling, a daily detailed driller's report shall be maintained and delivered upon request to the Engineer at the well site. The report shall give a complete description of all formations encountered, number of feet drilled, number of hours on the job, volume and weight of grout, volume of sand pack, shutdown due to breakdown, feet of casing set, and feet of screen set. Contractor shall also measure and record the top of sand pack and screen locations.

4.2.2.11 MEASUREMENT AND PAYMENT - Measurement and payment for drilling shall be based on completed well depths as the following items: Set-up, Drilling, Ground Water Sampling During Drilling, Geophysical Standby Time, and Providing and Installing Grout for Grouting Back Boring.

4.2.2.11.1 Payment For Set-up - Payment shall be a lump sum payment as specified in the Schedule of Charges for each boring completed. All costs for location on the well site shall be included in this item.

4.2.2.11.2 Payment For Drilling - Payment shall be made at the footage rate as specified in the Schedule of Charges. All costs for drilling the boring to the prescribed depths shall be included in this item. Measurement will be the depth of the hole specified by Engineer suitable for well construction.

4.2.2.11.3 Payment For Ground Water Sampling During Drilling - Payment shall be made at the hourly rates specified in the Schedule of Charges. The measurement will be the time from which Engineer informs Contractor that a ground water sample is to be collected until Contractor can reasonably resume his drilling operation. The time shall include the time required for the Contractor to remove his drilling tools, bail the water, collect the ground water sample, and reinstall his drilling tools.

4.2.2.11.4 Payment For Geophysical Logging Standby Time - Payment shall be made at the hourly rates specified in the Schedule of Charges. The measurement will be the time from which Contractor informs the Engineer that the boring is clean, stable, and ready to be geophysically logged until the geophysical contractor removes his equipment from the near vicinity of the boring and Engineer provides the information required for Contractor's work to proceed.

4.2.2.11.5 Payment For Providing and Installing Grout For Grouting Back Boring - Payment shall be made at the footage rates as specified in the Schedule of Charges. The measurement shall be the number of feet of grout installed. Minimum length of this unit shall be 40 feet.

4.2.3 INSTALLATION OF THE CASING AND SCREEN ASSEMBLY

4.2.3.1 GENERAL - The casing and screen assembly shall be constructed such that the screen will be located in the interval specified by the Engineer. The base of the screen shall be capped or otherwise closed to provide a positive seal. The casing shall extend from the top of the screen to a point 1.5 feet above the ground surface. The casing shall be closed at the top with a threaded female cap, which is attached to the casing with a suitable threaded male thread or adapter. The casing, fittings and screens shall be cut, assembled (insofar as possible), and measured prior to lowering any of the assembly into the boring. The Engineer shall be allowed to measure the assembled portions of the casing and screen assembly prior to their installation. The screen and casing assembly shall not touch the bottom of the boring after its installation has been completed.

4.2.3.2 INSTALLATION OF PVC CASING AND SCREEN - All couplings, adapters and other fittings shall be joined using mechanical screw joints. Proper care shall be taken to ensure that the PVC casing, screen or joints are not cracked or broken during their installation.

4.2.3.2.1 Measurement and Payment - Providing and installing the casing and screen assembly shall be based on completed well depth as items: Provide and Install Screen, and Provide and Install Casings.

4.2.3.2.2 Payment For Providing and Installing Screen - Payment shall be made at the footage rate specified in the Schedule of Charges and shall include all costs of providing and installing the screen. The measurement shall be the footage of screen specified by Engineer.

4.2.3.2.3 Payment For Providing and Installing Casing - Payment shall be made at the footage rates specified in the Schedule of Charges and shall include all costs of providing and installing the casing. The measurement shall be the footage of casing specified by Engineer.

4.2.4 PLACEMENT OF SAND PACK

4.2.4.1 GENERAL - Engineer will specify the location of the sand pack prior to installation of the casing and casing assembly.

4.2.4.2 TREMIEING SAND PACK - A temporary PVC tremie pipe placed outside of the screen-casing assembly shall be lowered with the screen and casing assembly to the bottom of the well. The tremie pipe shall have a minimum diameter of 1 inch. All necessary care shall be taken to prevent breaking and/or cracking the casing-screen assembly during tremieing operations and during withdrawal of temporary casing, if any.

4.2.4.2.1 Sand Pack Shall Be Added - At a constant rate and Contractor shall measure and/or otherwise keep an accurate record of the volume of sand pack placed. A sounder marked at 100-foot intervals and of adequate weight to positively feel the sand pack shall be used to keep track of the level of sand as it is being placed, and these measurements shall be correlated with the actual volume added.

4.2.4.2.2 As The Sand is Added - The tremie pipe may be withdrawn, but at no time shall the bottom of the tremie pipe be more than 20 feet above the top of the sand in the annulus. The sand shall be placed in the annulus up to a depth specified by the Engineer.

4.2.4.3 MEASUREMENT AND PAYMENT - Providing and installing the sand pack shall be based on completed well depth as the item: Provide and Install Sand Pack. Payment for providing and installing sand pack shall be made at the rate specified in the Schedule of Charges and shall include all costs of providing and installing the sand pack. Measurement shall be the footage of sand pack specified by Engineer.

4.2.5 INSTALLATION AND PLACEMENT OF GROUT SEAL

4.2.5.1 GENERAL - A grout seal shall be installed in the annulus between the casing and the borehole. Prior to installing the grout, a five-foot bentonite seal shall be placed above the sand pack. Bentonite pellets such as those manufactured by American Colloids shall be used to form the bentonite seal. The grout seal shall extend from the top of the bentonite seal to the ground surface.

4.2.5.2 TREMIEING GROUT - The grout must be tremied to within five feet of the top of the bentonite seal. The tremied pipe shall be kept at all times within the grout while the grout is being introduced. All necessary care shall be taken to prevent breaking and/or cracking the well casing-screen assembly during tremieing operations and during withdrawal of temporary steel casing, if any.

4.2.5.3 MULTIPLE GROUT POURS - Due to the low collapse pressure of PVC casing, multiple pours of grout may be required. When the length of the grout seal exceeds 200 feet, the grout shall be allowed 24 hours to set between each successive grout pour.

4.2.5.4 MEASUREMENT AND PAYMENT - Providing and installing grout seals shall be based on completed well depths as items: Provide and Install Grout and Additional Grout Pours.

4.2.5.4.1 Payment For Providing and Installing Grout - Payment shall be made at the footage rates specified in the Schedule of Charges and shall include all costs of providing and installing the required grout and bentonite seals, except for those costs identified for additional grout pours. The measurement shall be the footage of grout and bentonite seal specified by Engineer.

4.2.5.4.2 Payment For Additional Grout Pours - Payment shall be made at the lump sum price specified in the Schedule of Charges and shall include all costs for making multiple grout pours to obtain the total length of the grout seal. Specifically, it shall include extra cost for mixing, tremieing and standby-time required to make multiple grout pours. All costs for grout shall be included in the item Provide and Install Grout. Measurement shall be the number of additional grout pours required by the Engineer.

4.2.6 INSTALLATION OF PROTECTIVE WELL COVER AND MARKERS

4.2.6.1 GENERAL - A protective well cover shall be installed over the monitoring well. The cover shall extend from 2 feet below grade and to 1.5 feet above grade. A hole with a diameter of 1 foot and having a depth of approximately 2 feet shall be dug around the well. The cover shall then be placed over and symmetrically around the well and shall be cemented in place using a properly prepared concrete mixture. A concrete pad having a minimum diameter of 2 feet and a minimum thickness of 0.5 feet shall be placed around the protective well casing. A marker post shall be cemented in a separate hole having a minimum diameter of 6 inches and a depth of at least 2 feet. The location of the marker post shall be designated by the Engineer.

4.2.6.2 MEASUREMENT AND PAYMENT - Payment for each complete installation of well cover and markers shall be made as a lump sum at the rates specified on the Schedule of Charges for the item: Provide and Install Surface Completion. All costs for providing and installing the protective well covers and markers shall be included in this item. Measurement will be the number of wells on which protective covers and markers have been installed.

4.2.7 WELL DEVELOPMENT

4.2.7.1 GENERAL - After the complete installation of the well, the well is to be cleaned of all sand, clay and other materials which may have accumulated in the well. The well shall be pumped or bailed for a length of time sufficient to remove any drilling fluids introduced into the borehole during the drilling procedures. The removal of a minimum of 20 casing volumes will be required. The well shall not be considered developed until the water removed from the well is reasonably free of sand, silt and clay, and Contractor warrants that the well can be pumped using submersible pumps without damage to the pumps.

4.2.7.2 MEASUREMENT AND PAYMENT - Payment for well development shall be made as a lump sum payment at the rates specified on the Schedule of Charges for the item: Well Development, and shall include all costs for completing the development of the well as specified. Measurement shall be the number of wells in which the development has been completed.

4.2.8 SITE RESTORATION

4.2.8.1 GENERAL - After completion of all work installing the monitoring well, all unused materials and refuse resulting from Contractor's work shall be removed from the well site and properly disposed of. The Contractor will fill all pits excavated.

4.2.9 ADDITIONAL FOR EXTRA WORK

4.2.9.1 GENERAL - The object of these specifications is to outline the work and materials needed for the complete installation of monitoring wells. Payment for the construction of these wells will be based solely on the bid items listed in the Agreement. Materials, equipment and labor required to complete these wells and install pumps that are not specified in these specifications shall not be considered as additional or extra work. Only work that is specifically authorized, in writing, by the Engineer will be considered as additional extra work.

4.2.9.2 PAYMENT - Payment for extra work will be based on hourly rates for the crew and drilling equipment listed in the Schedule of Charges of this Agreement. All material costs and/or leased equipment shall be furnished on a cost plus basis, at cost plus five percent of cost. Drilling equipment includes all tools and equipment normally used in the installation of the prescribed monitoring wells. Refer to sections "General Conditions and Provisions" (Section 2.0) and "Special Conditions and Provisions" (Section 3.0) for specific information concerning payment for materials, services and equipment provided and/or leased on a cost plus basis.

4.2.10 STANDBY-TIME

4.2.10.1 GENERAL - Standby-time shall be allowed only for time periods in which Contractor is unable to use Contractor's drilling equipment and tools. Standby time will be charged only while awaiting and during the geophysical logging of the monitoring wells (see Section 4.2.2.10.3) or during time periods in which Contractor is unable to proceed because Contractor is waiting for information or services to be provided by the Engineer or Owner as detailed in these specifications. Only periods of time in which all equipment and crews are available shall be charged as standby time. Contractor shall give Engineer immediate written notice of the cause and duration of any standby time charges for the Engineer's written approval of standby time charges. Engineer shall not unreasonably withhold approval of standby time charges.

4.2.10.2 PAYMENT - Payment for standby time will be based on the hourly rates specified in the Schedule of Charges listed in the Agreement. A maximum of 8 hours per working day will be allowed.

4.2.11 MOBILIZATION AND DEMOBILIZATION

4.2.11.1 GENERAL - Mobilization and demobilization shall include all work and costs required to mobilize and demobilize from or to the site all equipment, materials, vehicles, trucks, drills, drilling supplies and crews necessary to complete the work required in this Agreement.

4.2.11.2 PAYMENT FOR MOBILIZATION AND DEMOBILIZATION - A single sum payment shall be made for mobilization to the site and demobilization from the site. The payment will be based on the Schedule of Charges for this cost listed in the Agreement.

TABLE 1

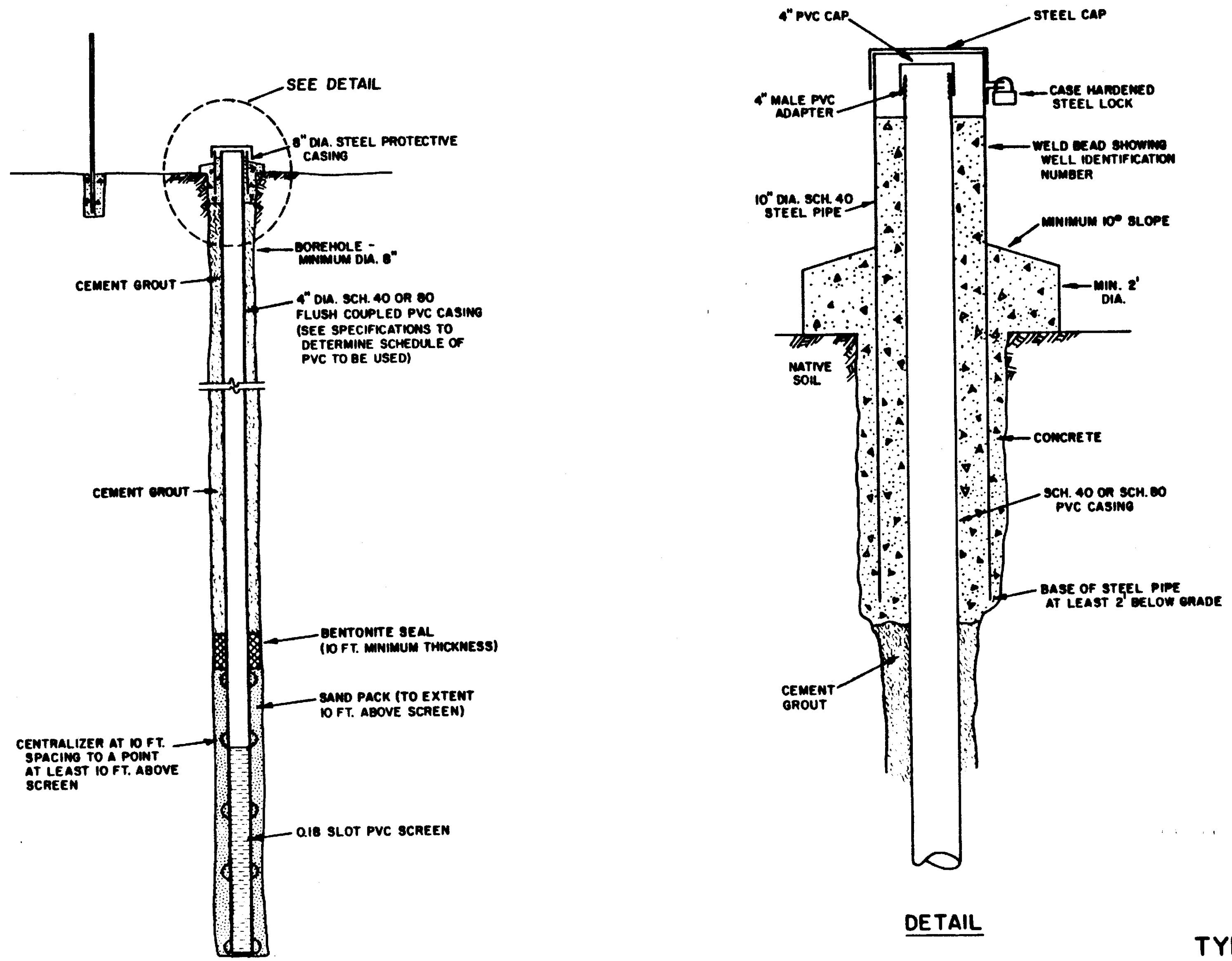
ESTIMATED WELL DEPTHS

Well Designation	Geologic*** Units	Estimated*** Well Depth (in feet)	Anticipated*** Screen Interval (in feet)
1S	Tv	160	110 - 160
1I	Tv	300	260 - 300
1D	Tv	360	340 - 360
2S	Tal, Tv	120	80 - 120
3S	Tv	120	80 - 120
4S	Tal, Tv?	220	180 - 220
5S	Tal, Tv?	220	180 - 220
5I	Tal, Tv?	300	260 - 300
5D	Tal, Tv?	350	310 - 350
6S	Tal, Tv?	130	90 - 130
7S	Qal, Tal?	330	290 - 330
7I	Qal, Tal?	350	320 - 350
8S	Qal	220	180 - 220
8I	Qal	300	260 - 300
9S	Qal	160	120 - 160
10S	Qal	300	260 - 300
10I	Qal	350	320 - 350
11S	Qal	300	260 - 300
11D	Qal	350	310 - 350
13S	Qal	50	25 - 50
13D	Qal	300	260 - 300
14S	Qal	150	110 - 150
14D	Qal	300	260 - 300
15S	Qal	350	320 - 350
16S	Qal	200	160 - 200
16I	Qal	300	260 - 300
17S	Qal	125	105 - 125

* See Disclaimer (Section 4.2.2.5.4)

** Geologic Units
- Qal - Quaternary alluvial and sediments of Lake Bonneville
- Tal - Tertiary alluvial sediments
- Tv - Tertiary volcanic rocks (may include some intrusive igneous rocks)

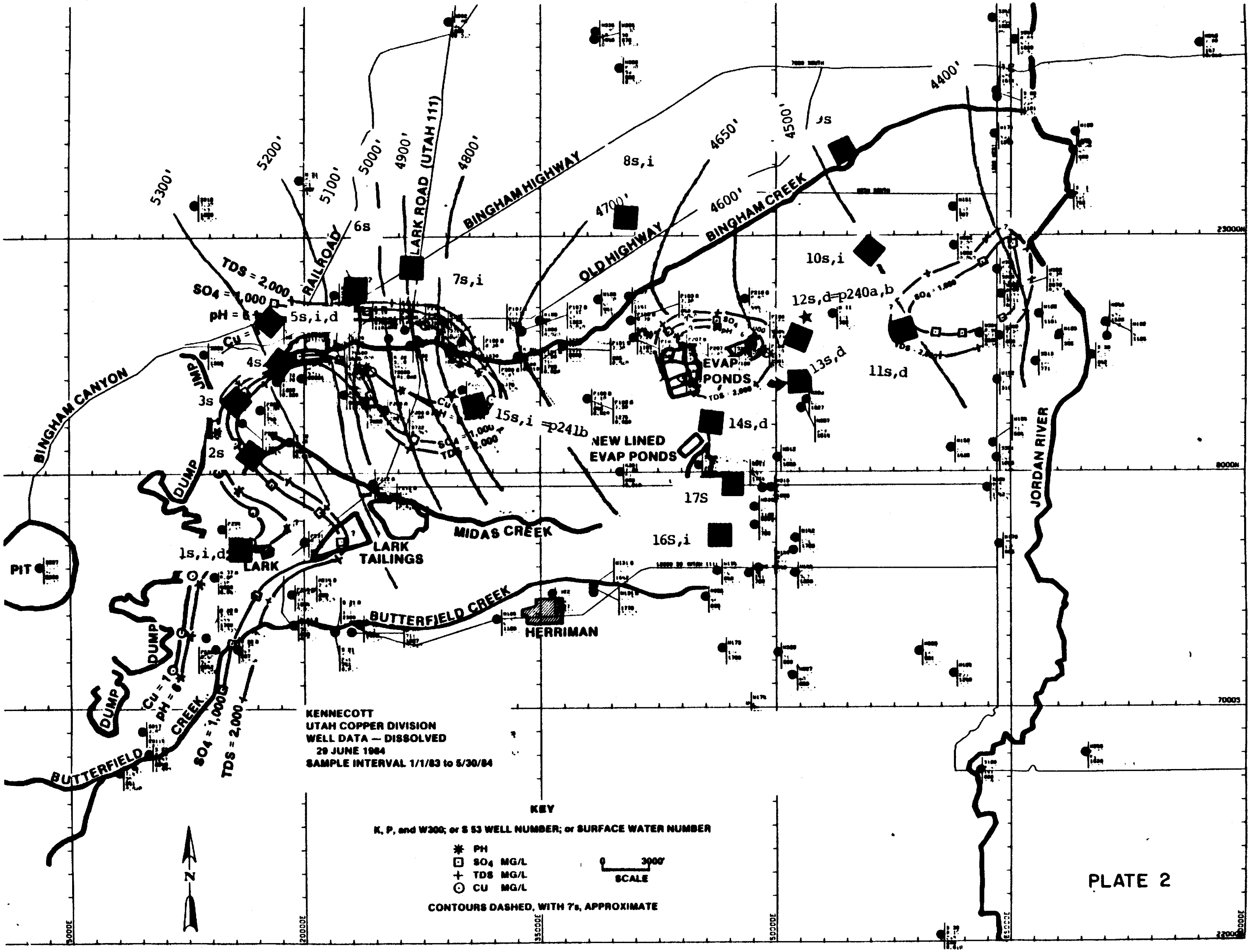
*** Final depths will not be specified by Engineer during course of drilling based upon subsurface conditions encountered.



TYPICAL
MONITOR WELL

Dames & Moore

PLATE 1



650' ___ Water level contour

PROPOSED WELL SITES FOR PHASEI DRILLING

WELLS ALREADY COMPLETED IN 1984